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CANNON AND HAIL.

By Prof. J. R. PLUMANDON, Professor at the University of Clermont-Ferrand and Meteorologist at the Observatory of the Puy de Dome, France, dated January 18, 1903.

From the most ancient times men have had the audacity to fight against storms by threatening Heaven with their weapons. In the time of Herodotus they hurled arrows in the air, to-day they discharge cannon. It is true that they no longer hope to intimidate an angry divinity, but they are convinced that they will be able to conquer nature and destroy storms.

Firing cannon to protect the crops from hail is a usage that goes back to the sixteenth century at least, and which has up to the present time passed through many alternate phases of success and failure, or even periods of complete oblivion. For the last few years we have been witnessing an extraordinary revival of this practise which has acquired a remarkable development in Austria, Italy, and even in some departments of France.

In 1880 and 1884, M. Bombicci, Professor of Mineralogy in the University of Bologna, Italy, maintained that it was possible to prevent the formation of hailstones during thunderstorms by the discharge of cannon which would carry the dust that causes condensation into the midst of the clouds. Some years later, about 1891, basing his views upon the experiments made in Texas, U. S., by General Dyrenforth in order to produce rain, Bombicci even proposed the same method to dissipate hailstorms and force them to discharge only a beneficial rain, or, at most, harmless sleet.

On June 4, 1896, Bombicci's plan was put into execution by M. Stiger, Burgomaster of Windisch-Feistritz, Styria, who made use at first of simple slightly elongated mortars to bombard those clouds that looked stormy. Only a little rain fell, the clouds disappeared and the experimenters attributed this good result to the cannonading. The same results were obtained under analogous conditions in the course of that year, 1896, and also in 1897, so that the cannonading stations began to increase. They numbered 56 in 1898, and at that time mortars, lengthened by the addition of a bell-mouthed chimney, shaped like the trunk of a cone, were used. This is the type of cannon in use at present, and known as "agricole" (agricultural) or "grelifugue" (hail preventing) and which has been perfected so that it renders the firing convenient and rapid.

According to a translation by M. Ottavi, Deputy in the Italian Parliament, the following paragraph occurs in M. Prohaska's official report on the results obtained in Styria during the year 1898:

It may be stated that the firing has produced good results only at Windisch-Feistritz where the success of the two preceding years has been maintained. In the other localities it has not been at all satisfactory.

The negative results are all the more surprising since the firing was begun in time and carried on perseveringly. * * * However, although the experiments of 1898 do not justify us in coming to a definite conclusion as to the practise of firing into the clouds it is necessary to continue what has been begun.

CONGRESS OF CASALE IN 1899.

Notwithstanding these results, in general unfavorable to the idea of the protection of the crops by means of cannon, numerous associations for cannonading were formed in Italy, particularly in Venice, Lombardy, Piedmont, and Emilia. At the end of the year 1899 there were already more than 2000 cannon there, and the vine growers of upper Italy after the thunderstorm season was over, called together a special congress at Casale in order to make the results obtained by the firing known and appreciated. M. Ottavi, who a few months before had advised his compatriots not to be too hasty in following the example of Styria, accepted the presidency of the committee on organization of this congress. More than 600 delegates met at Casale in November, 1899, under the presidency of M. Bombicci, and voted nearly unanimously for the following order of the day.

The congress after having inquired into the results obtained by the experiments carried on in Styria, Dalmatia, Piedmont, Lombardy, Venice, Emilia, and Tuscany is convinced:

1.—That the cannonading has made the prospect for the solution of the great problem of preventing hail very encouraging.

2.—That the results attained this year could not be more full of promise.

The congress expresses the hope that the regions in which the first experiments have taken place this year may succeed in perfecting the means of protection, taking as a basis the experience already acquired.

CONGRESS OF PADUA IN 1900.

The conclusions of the previous congress were by far too optimistic, they raised the enthusiasm of the vine growers to the highest pitch and the cannonading began to spread into Hungary, Spain, and southeastern France. But it was especially in Italy that the number of cannon increased to a surprising extent. In less than one year, in the province of Venice, they increased from 446 to 1630; in Brescia from 260 to 1455; and in Trevisa from 87 to 1334, etc. In short, at the end of 1900, 10,000 cannon were distributed in groups among the vineyards of upper Italy, and 9,500,000 discharges had taken place. This tremendous agricultural artillery, unfortunately, did not work without accidents, and in Venice alone, where there were 3000 cannon, 7 deaths and 78 wounded were reported.

The increase in number of associations for cannonading as a protection against hail led to the calling together of a second international congress which took place at Padua at the end of November, 1900, under the presidency of M. Alpe, professor at the high school of agriculture, at Milan.

Among the papers communicated to the congress, one remarks especially the report of M. Pochetino, director of the station for the study of hailstorms established at Conegliano, in Venice, by the Italian Government. It merits particular attention, not only on account of the guarantee afforded by a control, at once scientific and official, but also because it gives a general idea of the value of the facts invoked for or against the efficacy of the cannon. M. Pochetino, after having cited a great many facts in regard to the action of the firing upon the formation of hail, divided them into five categories, viz:

First category.—Where notwithstanding regular firing, hail fell within the boundary of the protected region and caused a loss of more than ten per cent of the crop. To this category belong the facts observed at Volpago, June 22, 1902, where notwithstanding the fact that the cannon were fired 2250 times, a narrow ridge of hail crossed the protected region. The failure was still greater at Monastier on the 10th and 11th of August, since the 100 stations began to fire a half-hour before the storm and in spite of 6000 shots and charges of from 80 to 150 grams, a storm of extraordinary violence devastated that commune and the losses reached 90 per cent.

Second category.—Where the hail fell within the boundaries of the protected regions, but the firing was irregular. This class includes the defense of the communes of Mogliano, May 25; Collabriga, July 30; Castello di Godago, August 11; Castelfranco, August 11; Crespano, August 11, and Mogliano, August 11.

Third category.—Where the firing took place and very little hail fell, doing no damage, outside as well as inside of the protected region. This occurred at Panderoba and Tanaro, May 8, 15, 25; Caerano and Volpago, June 22; Vazziola, June 18; Fontanelle, Spreziano, Salgareda, and Monastier, July 8; Caraso, July 11, 21, and 23.

Fourth category.—Where the firing took place and no hail fell within the protected region, but in localities situated outside of its limits the hail was very severe: Monegliano, June 18; Conegliano, June 26; Castelfranco, July 18; Monastier, August 7; Villorba, August 11.

Fifth category.—Where the firing was irregular and the damage was less severe around the firing stations. This comprises the partial successes of Gajarine, July 8, and of Losson du Molo, August 11.

The following are the personal opinions of the reporters for the various regions, as quoted from the report of M. Houdailles, delegate to the Congress of Padua for the Minister of Agriculture of France:

Austria.—M. Suschnig, Director of the Iron Works of Ste. Catherine on the Lamming, Styria, concludes by saying "that it is necessary to seek to explain the effects of the cannonading, which are still unknown to us."

Hungary.—M. Raum, First Assistant at the Observatory of Budapest, does not think that he can give a definite opinion as to the efficacy of the cannonading, “for,” says he, “we can not be too prudent as regards this question.”

France.—M. Guinand declares that “if complete protection under all possible circumstances can not be assured, at least it can not be denied that results of great importance have been obtained and that they constitute important indications for the future.”

Piedmont.—M. Rizzo, Professor at the University of Pérouse, concludes his report by saying that “up to the present time the facts collected and verified are not yet sufficient to furnish a solution to the problem of the efficiency of the cannonading.”

Lombardy.—M. Tamaro, Director of the Agricultural College at Crumello del Monte, maintained that “recent facts, confirmed by thousands of stations, can but serve to establish perfect confidence in the protection of the crops by cannon, and he hoped that when the congress was over no doubts would remain as to the efficiency of the firing.”

M. Sandri, Director of the Agricultural College of Brescia, went even further, and, as a consequence of the proofs of the efficacy of the shooting, he called for a vote recommending a law that should render obligatory the protection by cannonading when this protection is demanded by a majority of those interested.

Venice.—M. Pochetino, director of the stations for the study of hailstorms at Conegliano, declared that “it is impossible to pronounce, from a scientific point of view, as to the efficacy of the firing, and that this question can only be really practically demonstrated by statistics of actual damages, studied with care and impartiality, with the aid of observations collected for several years.”

M. Arina, Director of the Agricultural School at Susegana believes that the protection of the crops by the firing of cannon is destined to achieve substantial success in the future, but he recommends that no new syndicates for cannonading be formed and that those already existing be improved. He also proposes the establishment of experimental zones in order to insure more accurate data as to the efficacy of the shooting against hail.

Other provinces in Italy.—MM. Tagò and Marenghi, Professors of Agriculture, admitted that the system of cannonading was established on a solid basis, and that when the organization shall have been perfected, it will be successful, at least in cases of ordinary thunderstorms.

The Congress of Padua, after the reading of the various reports, as well as the testimony of the delegates as to the efficacy of the firing, adopted nearly unanimously, the resolution of M. Porro, Director of the Astronomical Observatory of Turin, as follows:

This congress, after having heard the reports and successive discus-

sions upon the results obtained during the year 1900, in Italy and in other countries, considers the great efficiency of shooting as a protection against hail as having been proved beyond all question.

As had already happened the year before at Casale, the conclusions of the Congress of Padua were far from being in perfect harmony with those expressed by the reporters. This arose from the fact that after each partial report the conclusions of the reporter were discussed and put to vote, but were generally adopted only after certain modifications that changed them considerably. The result was that in general the opinion of the assembly was substituted in an irrational manner for that of the reporters. The weight of the conclusions of this congress was thereby greatly diminished.

CONGRESS OF LYONS IN 1901.

Thanks to the persevering and persuasive activity of M. Guinand, Vice-president of Agricultural Union of southeastern France, who had participated in the congresses of Casale and of Padua, the use of cannon against hail continued to spread in France, especially in the Beaujolais where, in 1901, 300 cannon were in operation, covering a continuous region 10,000 hectares in extent. This enthusiasm was not, however, to be compared with that manifested in Italy, since over the whole of France it led to the establishment of only 834 cannon, of which 666 were in the departments of the Rhone, Saône et Loire, and Loire. It must, moreover, be admitted that even in Italy, doubtless as a consequence of previous efforts, the great ardor of the preceding years seemed not only to have subsided, but in some regions to have given place to a veritable discouragement.

The experiments of the year 1901 were the basis of a third international congress, and 1950 delegates met in Lyons on the 15th, 16th, and 17th of November, under the presidency of M. Burelle, President of the Regional Society of Viticulture. In the reports and discussions at the Congress of Lyons are found, even more than at the Congress of Padua, side by side with the ardent affirmations of the partisans of the efficacy of cannon against hail, the doubts and the wise reserve of those who wish for proofs; at times one heard even rather excited negations, proceeding from Italy as well as from France.

The following are some of the conclusions of the various reporters called upon to judge of the efficacy of the shooting, in the order in which they were presented to the congress:

France.—To-day the agricultural cannon seem to be able to clear up our viticultural horizon, arrest the thunder, the lightning, and the wind, disperse the clouds, and cause the sun to shine in a cloudless sky. This is the unanimous statement found in all the reports from our stations; it is certainly a fine work.—*M. Guinand, Vice-president of the Agricultural Union of the southwest.*

Austria.—All this does not suffice to enable us to consider the theory of cannonading as solved, and I share the opinion of our scientists who say that the efficacy of hail shooting can only be demonstrated by practise.—*M. Suschnig, Director of the Iron Works of Ste. Catherine on the Lamming.*

I can not prove scientifically whether the effect produced on the storm is due to chance or not, but I can prove that not a single stroke of lightning has occurred in the region provided with firing stations or in its neighborhood.—*M. Stiger, Burgomaster of Windisch-Feistritz.*

Italy: Piedmont.—At our local congress at Novara M. Rizzo, who has been studying the question on the spot for the past two years, told us that he has not yet been able to conclude with certainty that the discharges have any effect against hail. As to myself, I will say to you that I, on my part, have been studying the question in a practical manner for three years, that I have not had any hail, but I must ask you for still a few years more of observations and experiments before I can express a definite opinion.—*M. Ottavi, Deputy to the Italian Parliament.*

Italy: Lombardy.—The local congress of Novara, after having heard the reports on the shooting against hail, considers these as confirming the good results of 1899-1900, in regions where the associations have cannonaded regularly with sufficient means, and where no thunderstorms of exceptional violence have occurred. From this conclusion we may draw the inference that the problem of protection against hail is not entirely solved. In order to abridge the time and expense of the experiments it would be useful for the governments to organize completely and rationally several associations for cannonading, reserving to itself the right of official supervision of the results obtained each year. In this way alone the interpretation of observed facts would not be modified by the prejudices of those by whom they are examined and discussed, and the vineyardists would be correctly informed as to the efficacy of the practise of shooting toward the clouds. This is the expression of my personal opinion.—*M. Alpe, Professor of the High School of Agriculture of Milan, Ex-president of the Congress of Padua.*

Italy: Emilia.—In conclusion, I find that up to the present time we have not yet the reliable facts upon which one would be justified in asserting that the practise of cannonading has passed beyond the first stage of experimentation. No definite opinion whatever can be formed, even if the methods should be perfected, for from ten to twelve years from this time.—*M. Marescalchi, Director of the Coltivatore.*

Italy: Udina, Belluna, Trevisa, Verona, and Venice.—For my part, after having examined personally several of the principal cases and after having heard many accounts from different sources, I am perfectly convinced that whenever we have rational establishments equipped with suitable means of defense and with a staff of disciplined and intelligent officials we may combat ordinary hailstorms with every prospect of success.—*M. Marconi, Professor of Agriculture at Venice.*

Switzerland.—As a whole, the results obtained in Switzerland are still inconclusive. They are not, however, such as to discourage us, since there have not been any notable marked failures; on the contrary, in several cases the shooting seems to have produced some good effect. But an experience of one year does not prove anything. Many years of experiment at our various stations will be necessary before we can confidently state what the results of the cannonading really are.—*M. Dufour, Director of the Viticulture Station at Lausanne.*

Spain: Barcelona.—As regards the results in the region under protection, and although no severe hailstorms have occurred in which the decisive effect of the cannon could be demonstrated, nevertheless there have, at least, been several cases that make us hope for great success.

We see in the experiments thus far made results very favorable to the solution of a problem which is of interest to the agriculturists of the whole world, and our conviction is that the regions well supplied with cannon, properly distributed over their zone of action, will hereafter be able to protect their crops against hail, especially if, in addition to a good organization for the shooting, there prevail the enthusiasm and the faith which are necessary in order to achieve success among the agricul-

turists of the protected zone.—*M. Garcia de los Salmones, Director of the Agricultural Service of Navarre.*

Russia.—The land that has always suffered five or six times annually from hail has been entirely exempt from it this year, whereas in the surrounding regions the crops have been destroyed as usual. It is true that it is impossible to draw any conclusion as to the utility of the firing from the experience of a single year, but I am happy to be able to state that no case of failure has occurred to diminish the confidence first felt.—*Gogol-Janovsky, Director of the Vineyard of the Imperial Domains at Tiflis.*

After several other reports relative to the organization of zones of protection from the financial and legal point of view, M. Roberto, supervisor of education at Alessandria, Italy, and reporter general for Italy, concludes as to the efficacy of the cannon against hail in ordinary storms by admitting the impossibility of destroying very violent hailstorms.

M. Plumandon, reporter-general for all the countries represented at the congress, concludes that the proofs adduced in favor of the efficacy of cannon against hail are practically without any value; that this alleged efficacy seems to him very problematic and almost impossible; that finally in order to elucidate the question it is at least necessary to make the experiments in accordance with scientific methods, to accept no fact that had not been submitted to a severe investigation, and above all not to adopt any conclusion until it had undergone rigorous criticism and examination. After some remarks upon the organization of such supervision the reporter terminated by wishing success to the experimenters.

The reading of reports having been concluded, M. Burelle, President of the Congress, then addressed the reporters and said that the question of the employment of cannon against hail presents itself under conditions such that neither science nor agriculture can afford to ignore it. Animated by this thought he submitted to the vote of the congress the following resolution:

The Third International Congress on Hail Shooting, assembled at Lyons, November 15, 16, and 17, 1901, after having listened to the reports and the results obtained during the year 1901, in France, Austria, Hungary, Italy, Spain, Switzerland, and Russia, comes to the conclusion that the question of protection against hail is worthy of the attention and study of scientists and the confidence and hopes of agriculturists.

The congress adopted this resolution, together with several others, relative to the organization of the zones of shooting.

CONFERENCE AT GRATZ, 1902.

After the Congress of Lyons a calm succeeded to the general effervescence and the protection of crops by cannonading did not experience any notable increase. As regards France we may judge of this by the small increase in the number of cannon in Beaujolais, viz.: 340 cannon in 1901; 357 in 1902.



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However, in this connection an interesting event took place, viz., the meeting at Gratz (Styria) which was a conference of experts under the auspices of the Austrian Minister of Agriculture.¹

It would occupy too much time and space to enter in detail into the reports, experiments, and discussions with which the sittings were occupied, we shall, therefore, only call attention to the following table, which summarizes well and briefly the results of the labors of the conference:

Number of experts in whose opinion cannonading is efficacious	8
Number of experts in whose opinion the efficacy is still doubtful, but probable	9
Number of experts in whose opinion the efficacy is only doubtful ..	13
Number of experts in whose opinion the efficacy is not only doubtful, but improbable	15
Number of experts in whose opinion cannonading is entirely inefficient.....	5
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Conclusion.—The preceding paragraphs present as briefly as possible, the successive phases of the recent efforts made in Europe to destroy hailstorms by the aid of cannon. A simple comparison of the reports and conclusions which have appeared annually from 1898 to 1902, is very instructive and calls forth the following important remark, viz., that the thoughtless and ill-informed enthusiasm which distorted the first discussions on the efficiency of cannonading against hail has gradually given place to the calmer and more serious judgment which led the Congress of Lyons and still more the Conference of Gratz to conclusions more rational and more in harmony with the nature of the phenomena to be investigated as well as of observed facts.

It would be easy to explain the origin and spread of the first enthusiasm; why many sincere people were conscientiously brought to judge too favorably of experiments which did not prove anything; but that would lead to too much detail. The general statement, above given, which constitute, so to speak, the abridged history of the bombardment with cannon against hail, will suffice to show how circumspectly we must proceed when we wish to judge of the efficacy of human intervention against the great forces called into play by nature for the production of thunderstorms. They also show that we should not discount too quickly the advantages that we may hope to derive from such enterprises. If it were necessary to conclude by a plain unvarnished admonition, the following is what I would say: *Before undertaking the protection of your crops by cannonading, wait until that method of protection has furnished good results in countries where it is now being tried.*

¹This is published in full in an appendix to the annual volume for 1902 of the Central Institute for Meteorology and Terrestrial Magnetism.